# Case Study: Site Specific Criterion Selection for a Non-Anthropogenic Condition

## Madison River

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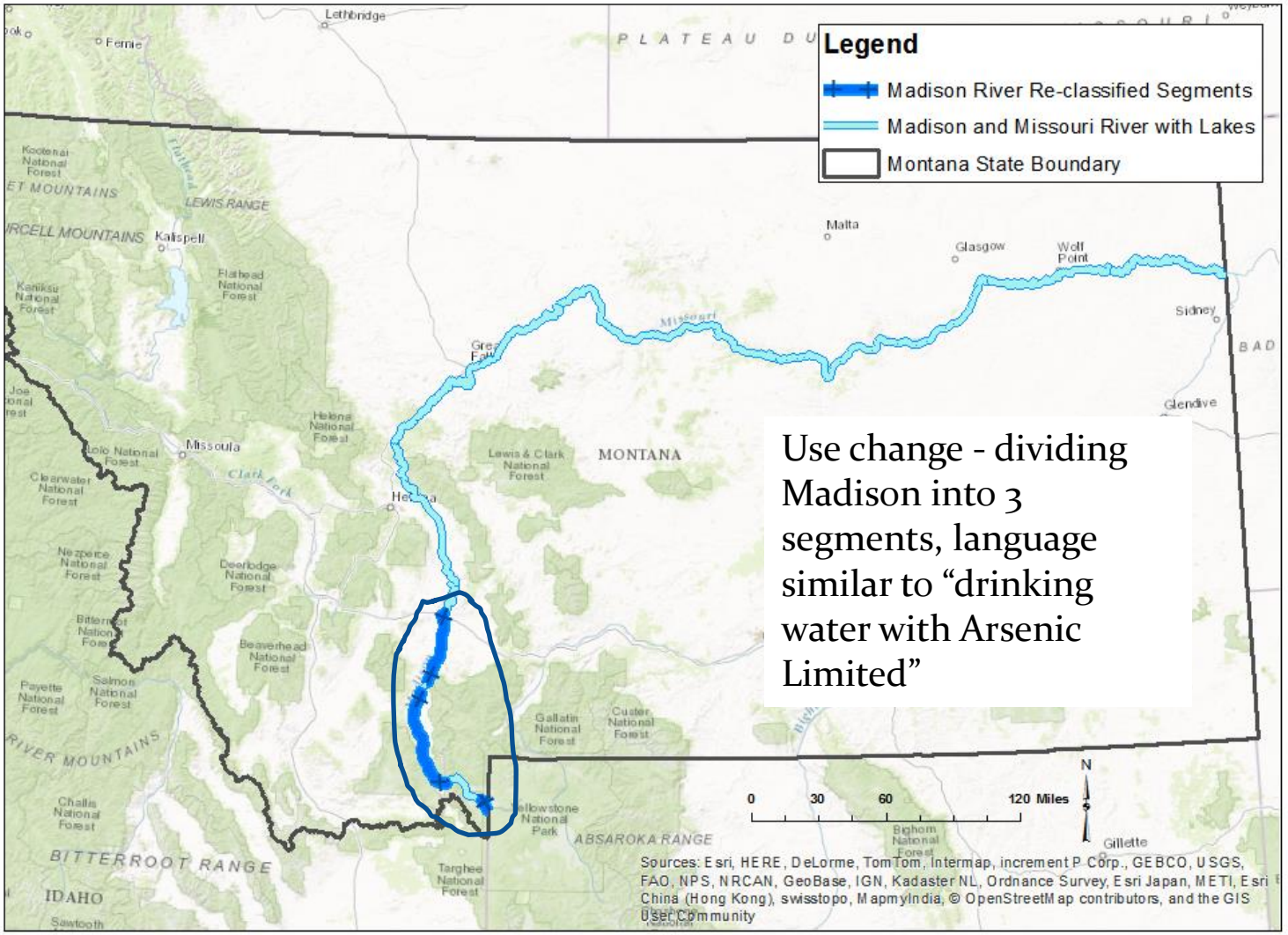
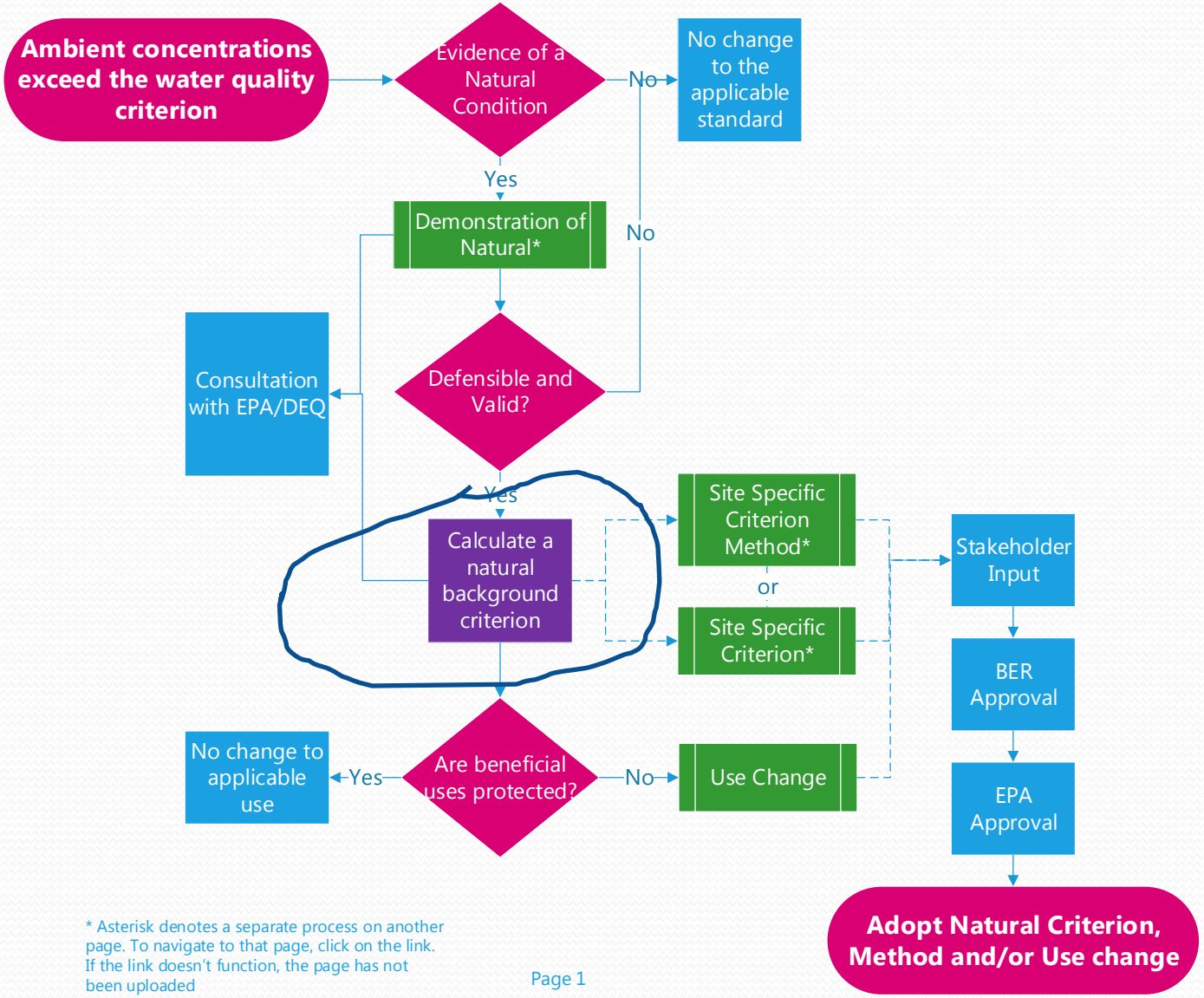
DEQ
Montana Department of Environmental Quality

# Re-Classified Segments for Madison River



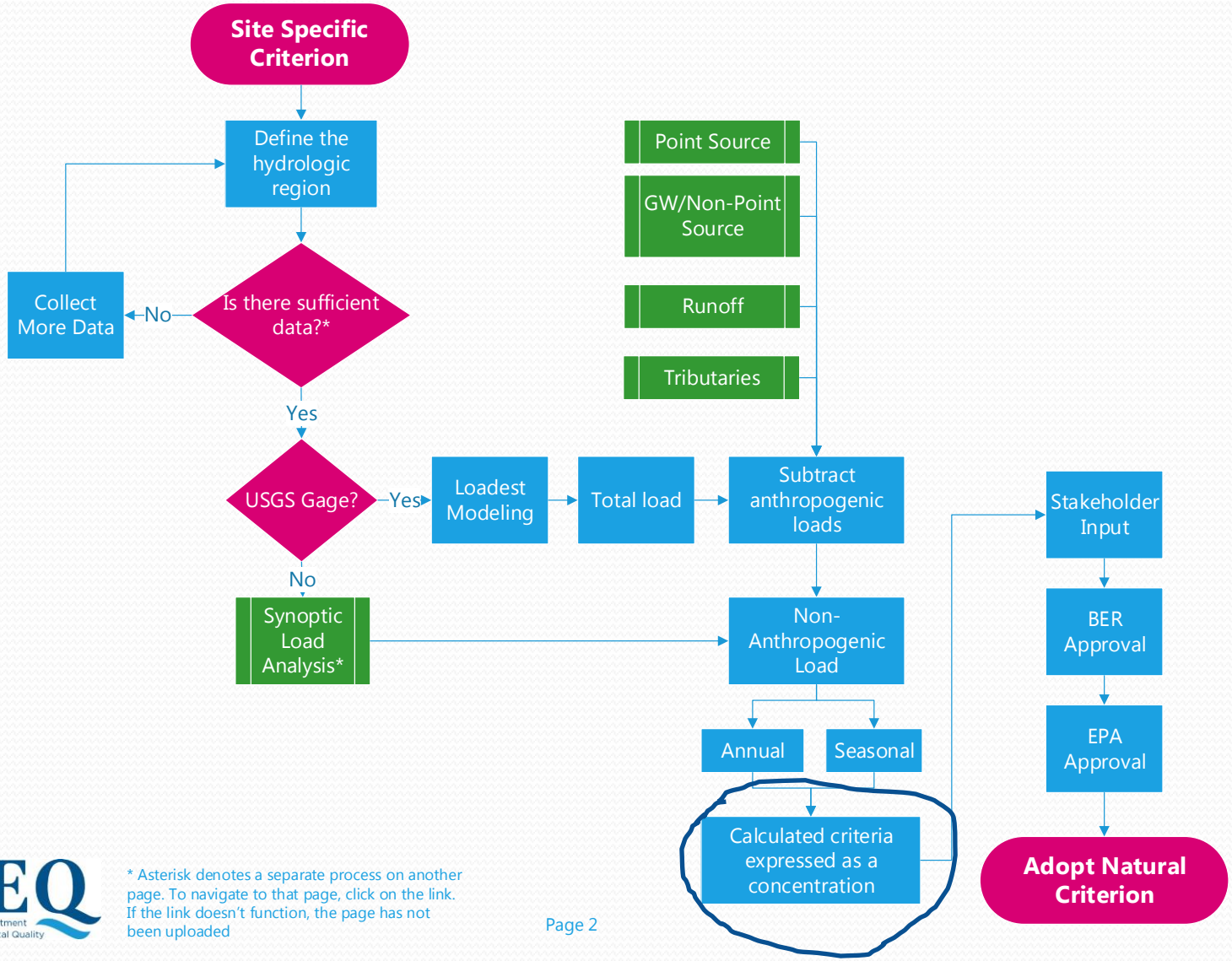
## Conceptual Model for Non-Anthropogenic Condition




* Asterisk denotes a separate process on another page. To navigate to that page, click on the link. If the link doesn't function, the page has not been uploaded

Page 1

## Conceptual Model for Site Specific Criterion

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# Ambient versus Non-Anthropogenic

- Ambient Condition– Concentration of the water body
- Non-Anthropogenic Condition– Subtracting Anthropogenic Sources
  - $\frac{1}{2} - \frac{1}{3}$
  - $\frac{3}{6} - \frac{2}{6} = \frac{1}{6}$
- Load - Common denominator for calculating a Non-Anthropogenic condition

# Calculating the Non-Anthropogenic Load

- Non-Anthropogenic Load = Total Arsenic Load – Anthropogenic Loads

  **ML = C x Q x t x cf**

  **ML** – Mass Load (pounds or kilograms)

  **C** – Concentration (ug/L or mg/L)

  **Q** – Volume of water at a point (cubic feet per second, cfs)

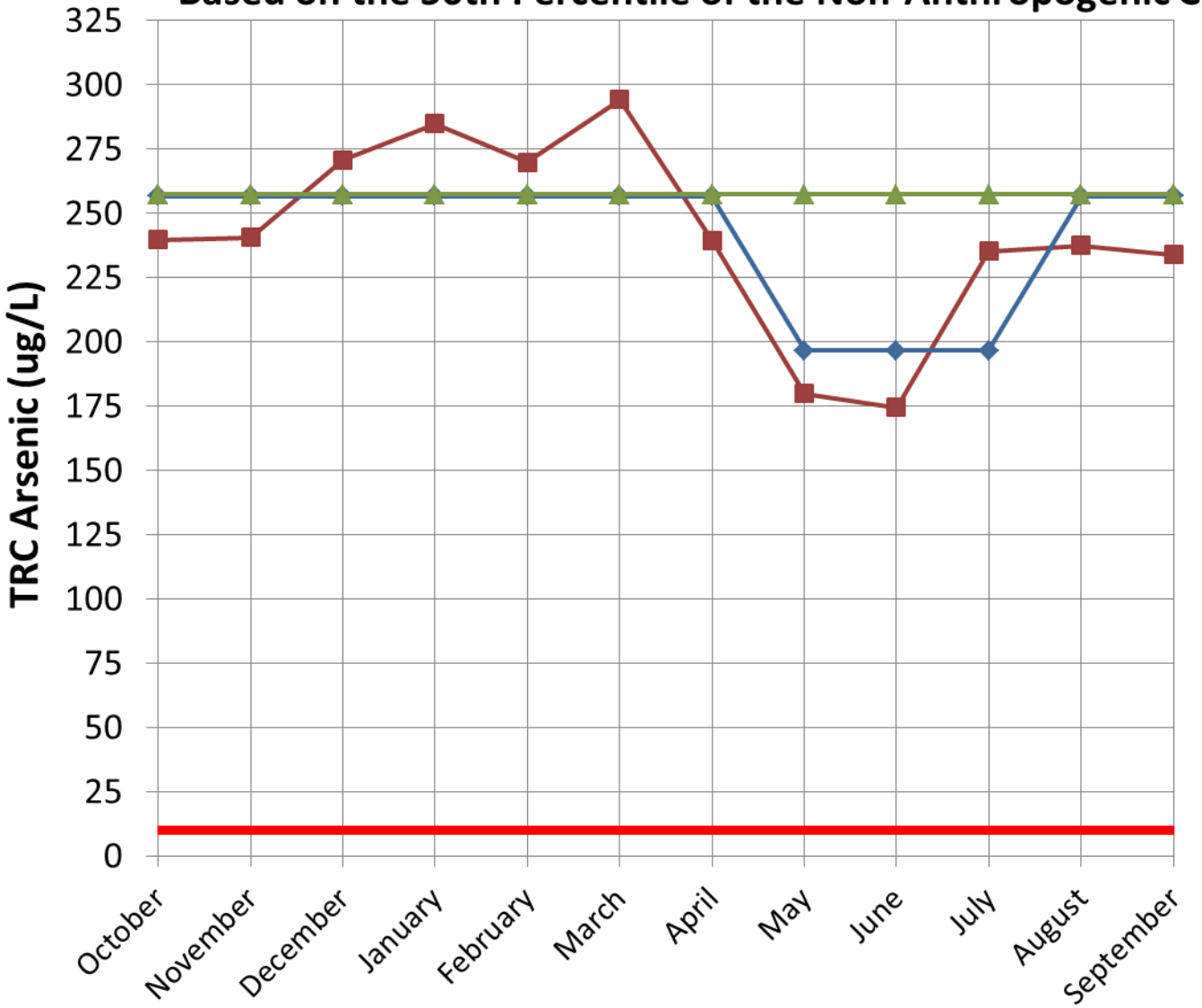
  **T** – A period of time (season, month, or year)

  **cf** – conversion factor for mass load calculation

- Non-Anthropogenic Load is converted back to a concentration using a flow condition

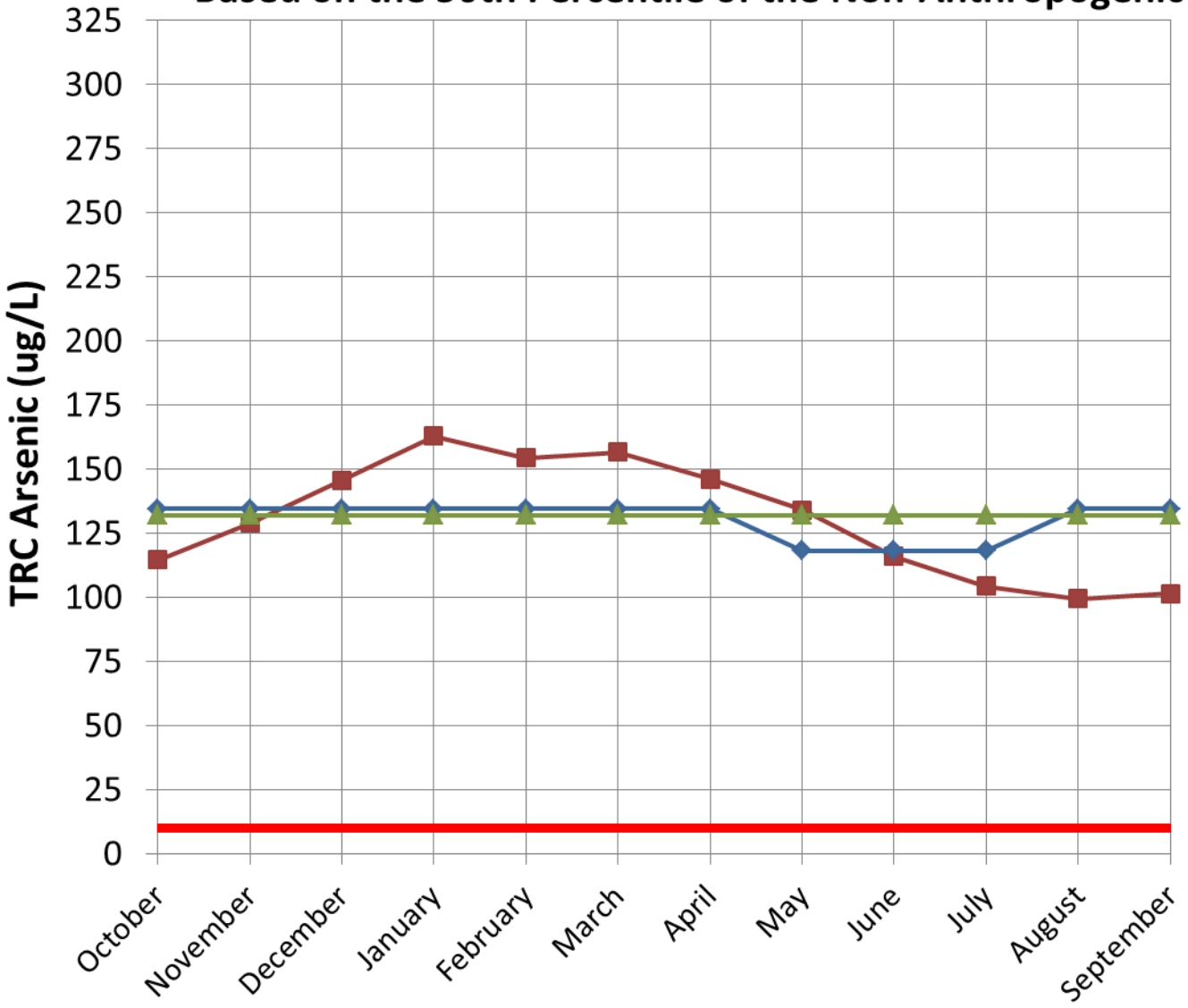
  **C = ML/(Q x t x cf)**

# Madison River,
# West Yellowstone to Below Hebgen Lake,
# Based on the 50th Percentile of the Non-Anthropogenic Condition



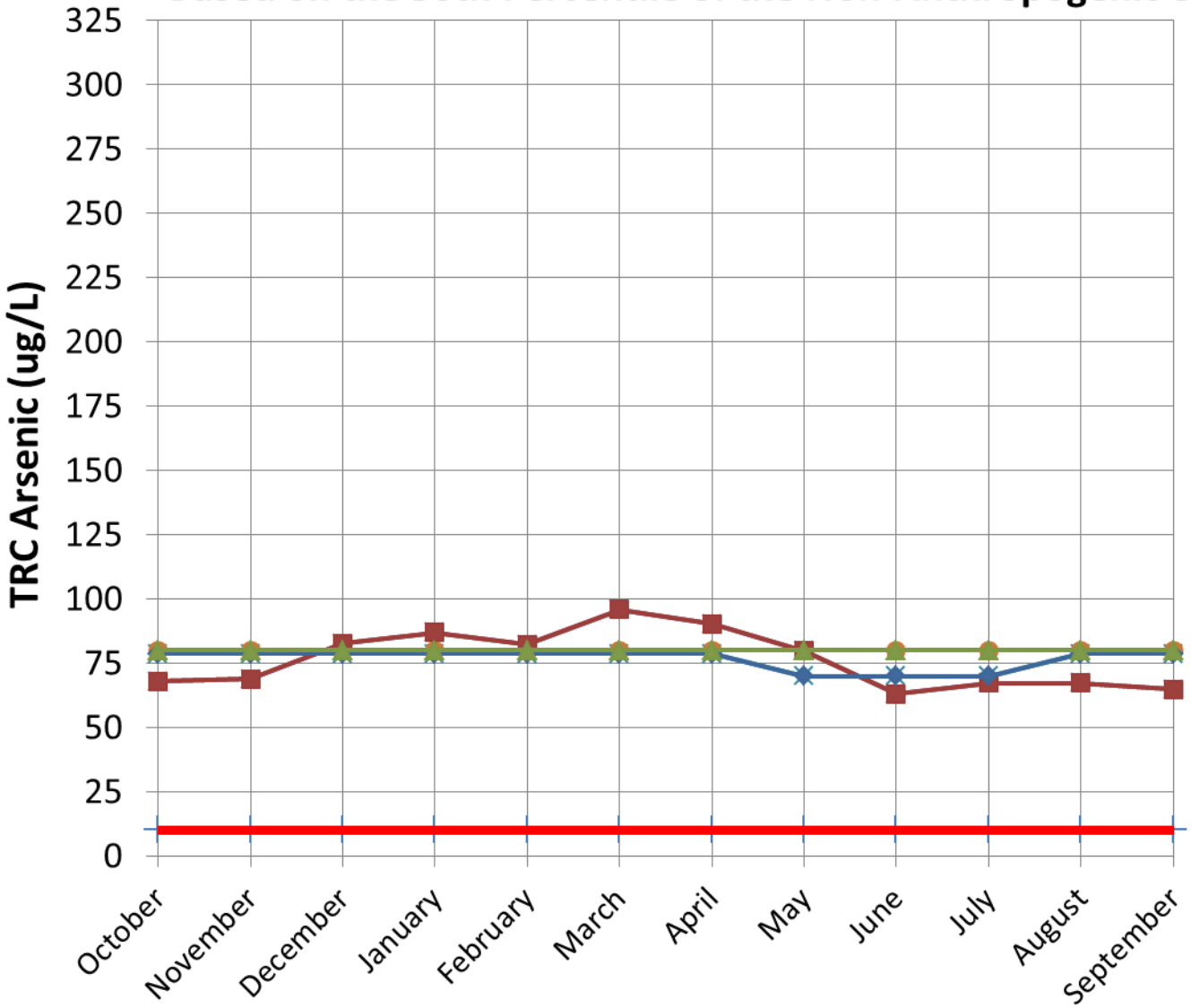

Total arsenic loads modeled using USGS LOADEST usind data from 1995-2015. Nonanthropogenic concentrations calculated from the 50th percentile of total arsenic loads and median flow rates for the Madison. Anthopogenic loads are based on an average monthly or

# Madison River,
# Below Hebgen Lake to Below Ennis Lake
# Based on the 50th Percentile of the Non-Anthropogenic Condition



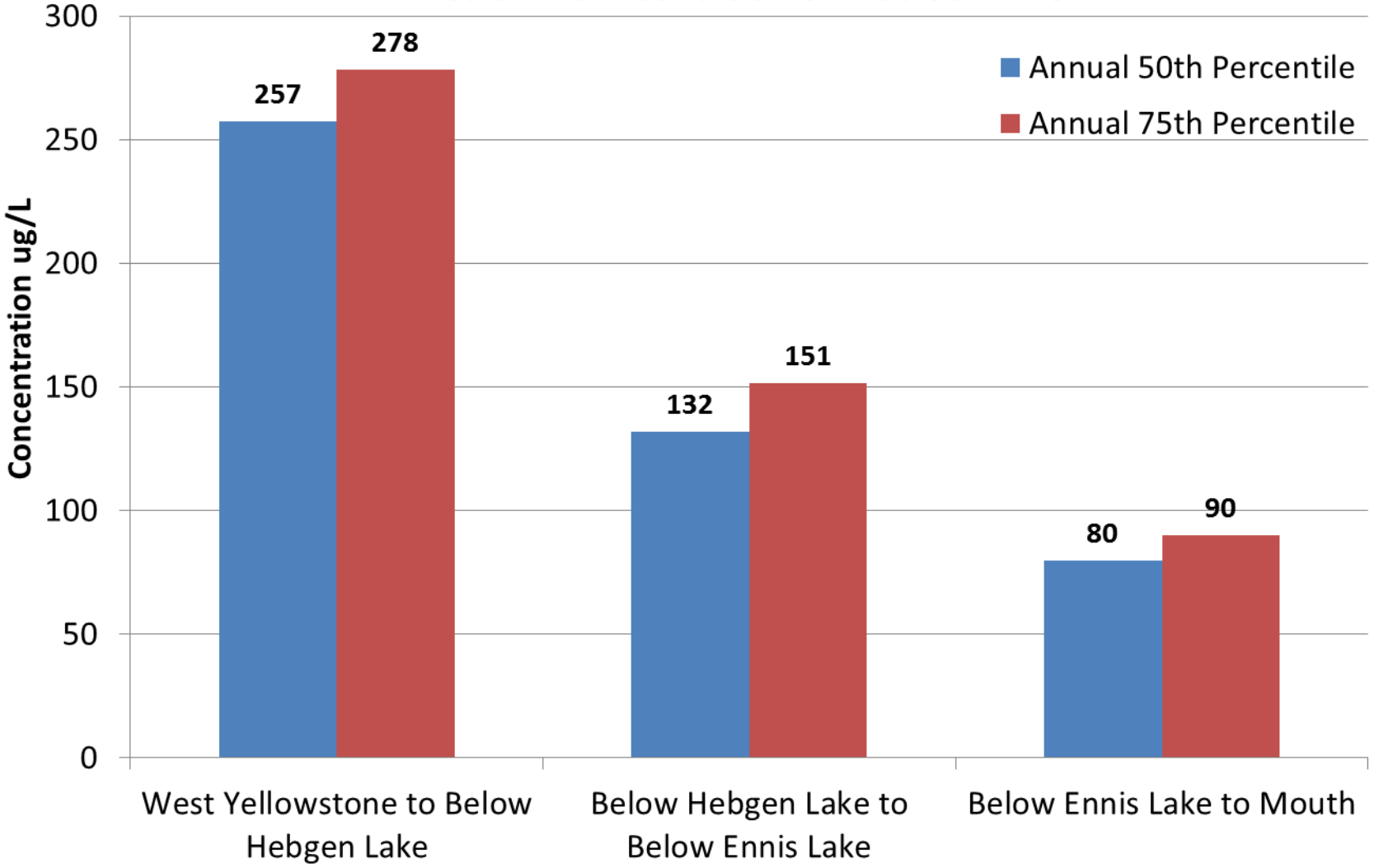

Total arsenic loads modeled using USGS LOADEST usind data from 1995-2015. Nonanthropogenic concentrations calculated from the 50th percentile of total arsenic loads and median flow rates for the Madison. Anthopogenic loads are based on an average monthly or

# Madison River,
# Below Ennis Lake to Mouth
## Based on the 50th Percentile of the Non-Anthropogenic Condition

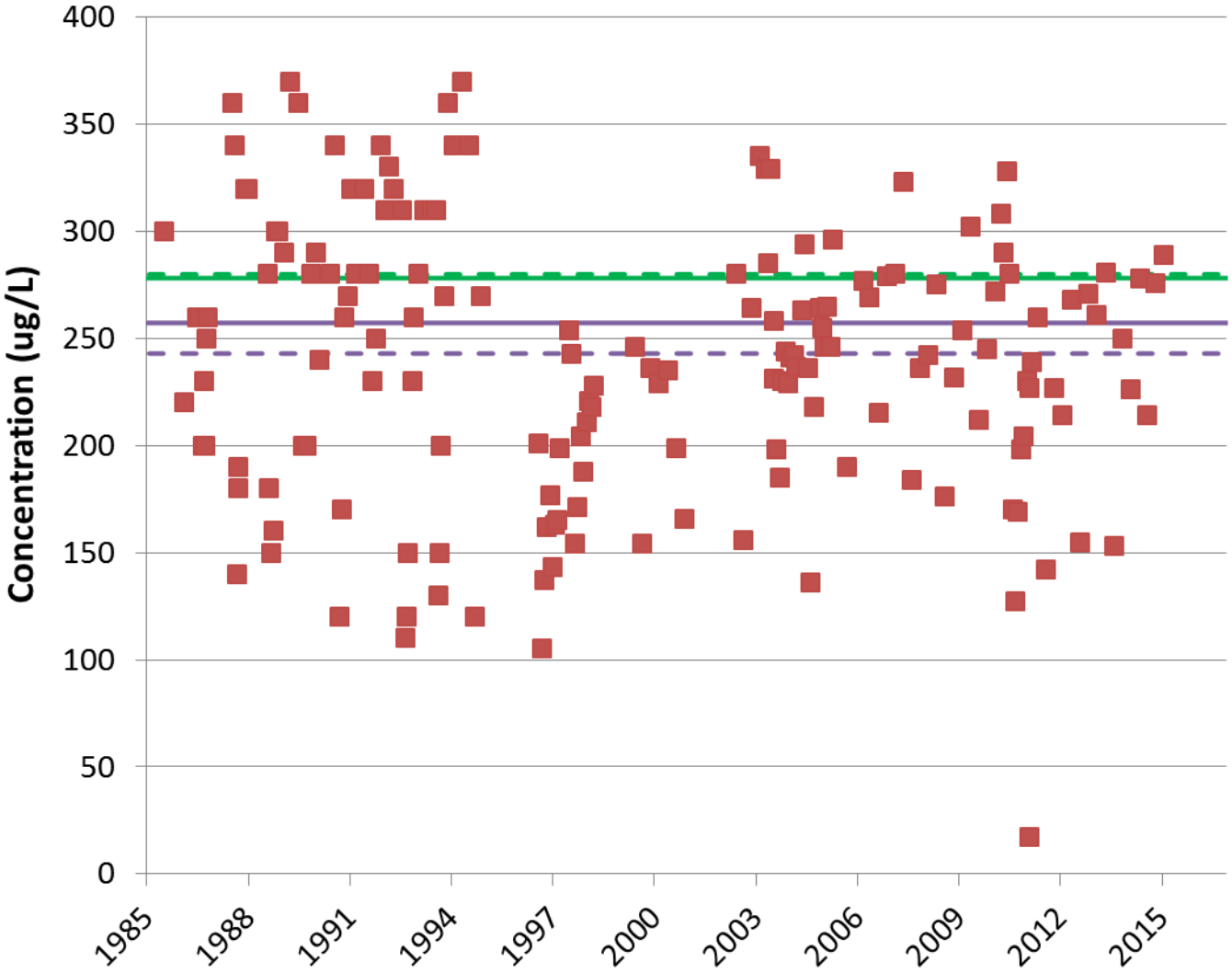



Total arsenic loads modeled using USGS LOADEST usind data from 1995-2015. Nonanthropogenic concentrations calculated from the 50th percentile of total arsenic loads and median flow rates for the Madison. Anthopogenic loads are based on an average monthly or

## Annual Nonanthropogenic Criterion for the Madison River, based on Median Flow Condition of Madison River

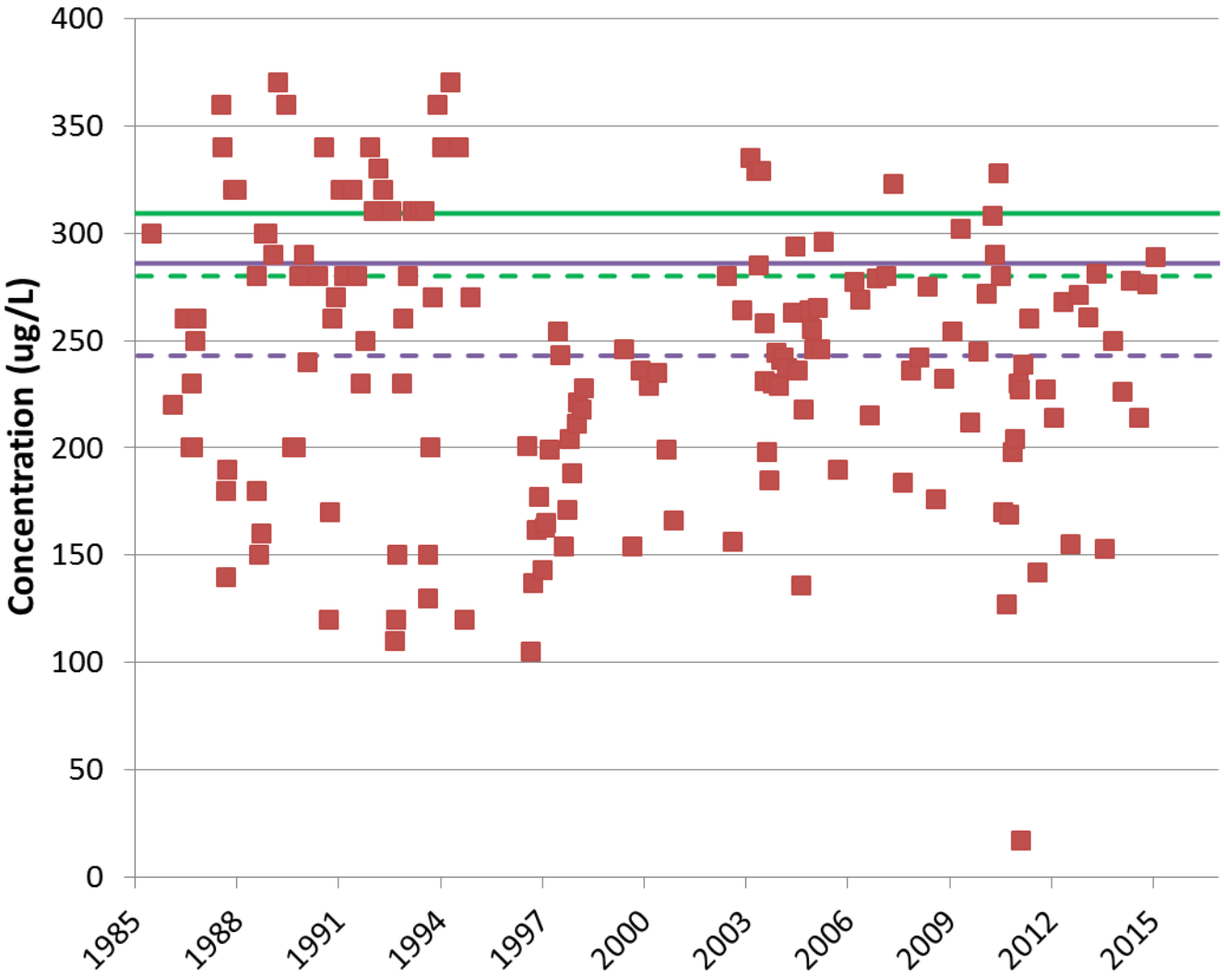


# Criteria Compared to Actual Data - Madison West Yellowstone to Below Hebgen Lake




Criteria calculated using modeled results and **50th Percentile** of daily flow data (1995-2015)

# Criteria Compared to Actual Data - Madison West Yellowstone to Below Hebgen Lake




Measured Concentrations above Hebgen Lake

50th Percentile of Measured Concentrations

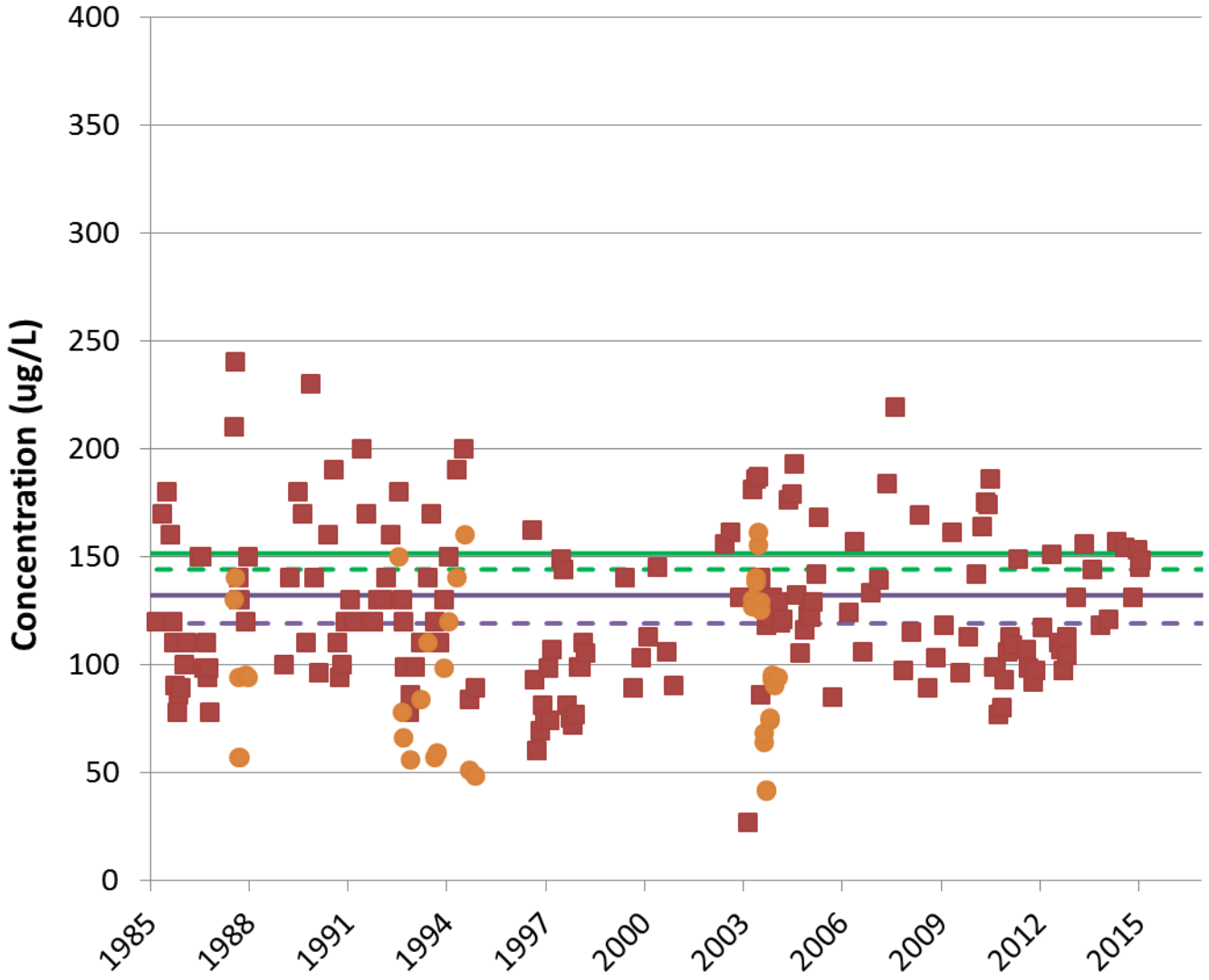
75th Percentile of Measured Concentrations

Criteria - 50th Percentile

Criteria - 75th Percentile

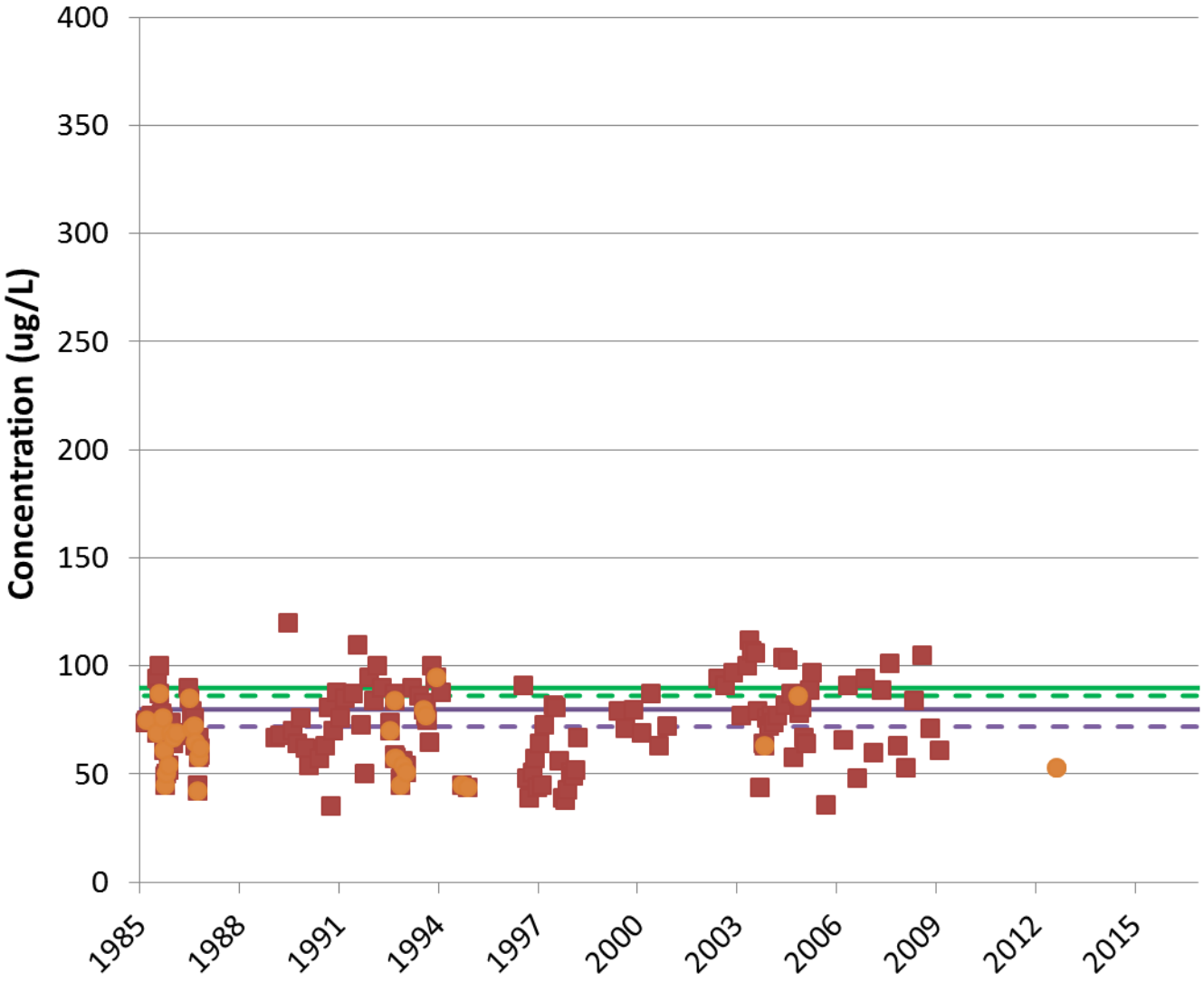
Criteria calculated using modeled results and **25th Percentile** of daily flow data (1995-2015)

# Criteria Compared to Actual Data - Madison Below Hebgen Lake to Below Ennis Lake




Criteria calculated using modeled results and **50th Percentile** of Daily Flow Data (1995-2015)

# Criteria Compared to Actual Data - Below Ennis Lake to Mouth




- Measured Concentrations below Ennis Lake
- Measured Concentrations at Mouth
- 50th Percentile of Measured Concentrations
- 75th Percentile of Measured Concentrations
- Criteria - 50th Percentile
- Criteria - 75th Percentile

Criteria calculated using modeled results and **50th Percentile** of Daily Flow Data (1995-2015)

# Madison River Total Arsenic Mass Balance Summary

## 50th Percentile

| | Total Arsenic Load | Non-Anthropogenic Load | Anthropogenic Load |
|---|---|---|---|
| Start: West Yellowstone (kg/year) | 98,594 | 98,594 | 0 |
| End: Mouth (kg/year) | 105,821 | 105,729 | 92 |
| Percent of the Total Arsenic Load | | 99.9% | 0.1% |

| | |
|---|---|
| Start to End Non-anthropogenic Mass Difference | 7,134 |
| Tributary Contribution | 3,327 |
| Unaccounted for Mass: Mass Difference minus Trib Contribution (kg/year) | 3,807 |
| Unaccounted for Mass: Mass Difference minus Trib Contribution (%) | 4% |

*Remainder of non-anthropogenic load is likely groundwater contribution, re-entrenchment of stream sediment during high flow events, and/or margin of error within mass balance calculations.

# Implementation

Assessments (example to follow)

Permitting

Remediation

# Assessment Example: Colorado Method

## Statistical Approach for Future Assessments

- Confidence interval is the region around an assessed concentration
- Increases the reliability of conclusions drawn from assessments
- Width of the confidence interval is determined by the desired level of confidence and the sample size
- 90% confidence interval would have a 10% probability (1 in 10 chance) of mistakenly concluding that the assessed concentration differs from the standard.
- 95% confidence interval would have a broader confidence interval but less risk (1 in 20 chance)

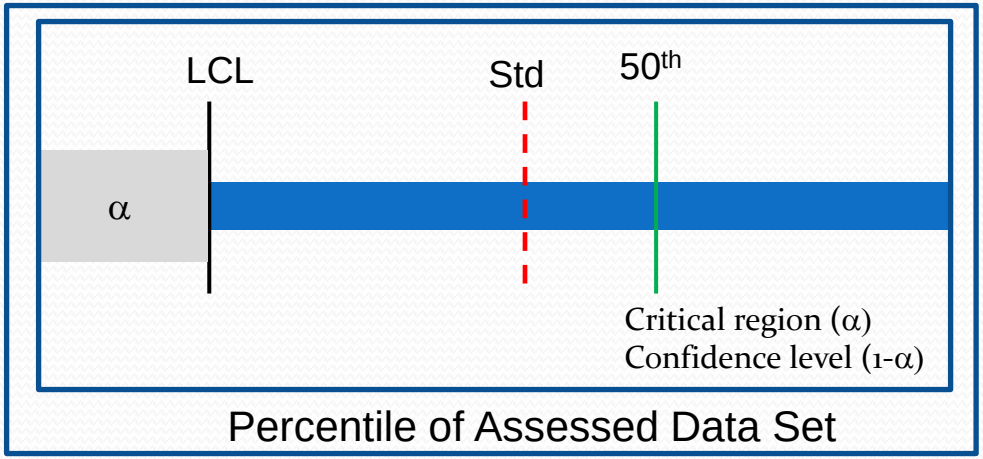
# Hypothetical Assessment for Madison West Yellowstone (1)

## *Small Dataset – Smaller LCL Factor*

| Date | TR Arsenic (ug/L) |
|---|---|
| 2/19/2023 | 268 |
| 5/14/2023 | 155 |
| 8/13/2023 | 271 |
| 11/19/2023 | 261 |
| 2/18/2024 | 281 |
| 5/20/2024 | 153 |
| 8/19/2024 | 250 |
| 11/18/2024 | 226 |
| 2/24/2025 | 278 |
| 5/19/2025 | 214 |
| 8/18/2025 | 276 |
| 11/17/2025 | 289 |

| **Ambient based annual standard, Adopted 2017** | **257 ug/L** |
|---|---|
| Assessed (2023-2025) 50th % | 265 ug/L |
| Sample Size | 12 |
| Outcome | Exceeded |

| Lower Confidence Limit Factor, 90% Confidence Interval | 0.265 |
|---|---|
| LCL Concentration for Assessed (2023-2025) 50th % | 224 ug/L |
| Outcome | Not Exceeded |




Adapted from WQCD, 2016

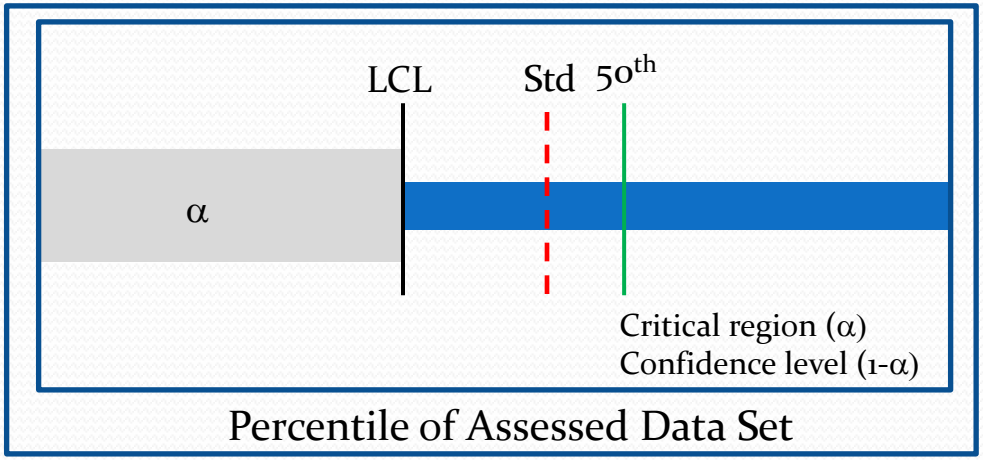
# Hypothetical Assessment for Madison West Yellowstone (2)

## *Large Data Set – Greater LCL Factor*

| Date | TR Arsenic (ug/L) | Date | TR Arsenic (ug/L) |
|---|---|---|---|
| 1/20/2026 | 290 | 9/17/2026 | 232 |
| 2/4/2026 | 300 | 10/2/2026 | 236 |
| 2/19/2026 | 320 | 10/17/2026 | 238 |
| 3/6/2026 | 310 | 11/1/2026 | 240 |
| 3/21/2026 | 270 | 11/16/2026 | 258 |
| 4/5/2026 | 290 | 12/1/2026 | 260 |
| 4/20/2026 | 280 | 12/16/2026 | 262 |
| 5/5/2026 | 270 | 12/31/2026 | 270 |
| 5/20/2026 | 175 | 1/15/2027 | 253 |
| 6/4/2026 | 190 | 1/30/2027 | 260 |
| 6/19/2026 | 175 | 2/14/2027 | 250 |
| 7/4/2026 | 209 | 3/1/2027 | 280 |
| 7/19/2026 | 266 | 3/16/2027 | 275 |
| 8/3/2026 | 243 | 3/31/2027 | 267 |
| 8/18/2026 | 234 | 4/15/2027 | 260 |

| **Ambient based standard, Adopted 2017** | **257 ug/L** |
|---|---|
| Assessed (2023-2025) 50th % | 260 ug/L |
| Sample Size | 30 |
| Outcome | Exceeded |

| Lower Confidence Limit Factor, 90% Confidence Interval | 0.365 |
|---|---|
| LCL Concentration for Assessed (2023-2025) 50th % | 252 ug/L |
| Outcome | Not Exceeded |



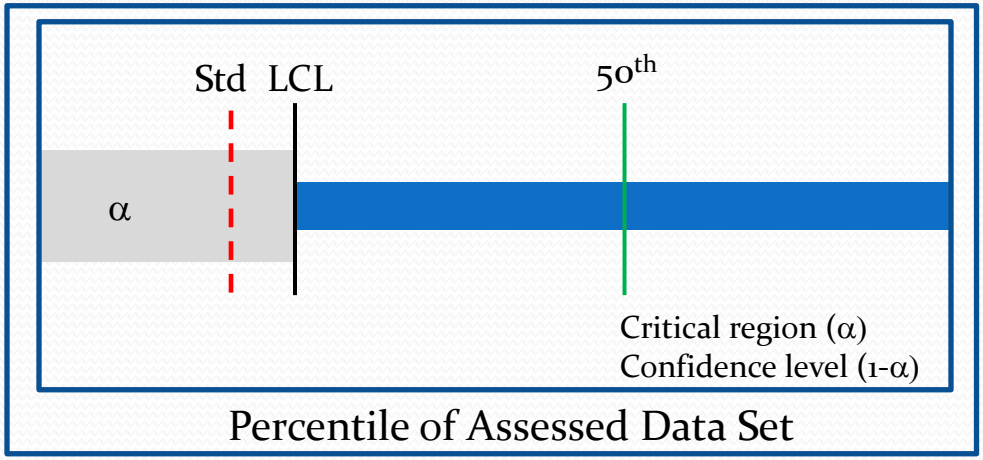

Adapted from WQCD, 2016

# Hypothetical Assessment for Madison West Yellowstone (3)
## 90% Confidence – Narrower Confidence

| Date | TR Arsenic (ug/L) |
|---|---|
| 4/30/2028 | 295 |
| 5/15/2028 | 270 |
| 5/30/2028 | 274 |
| 6/14/2028 | 273 |
| 6/29/2028 | 271 |
| 7/14/2028 | 249 |
| 7/29/2028 | 246 |
| 8/13/2028 | 248 |
| 8/28/2028 | 246 |
| 9/12/2028 | 252 |
| 9/27/2028 | 253 |
| 10/12/2028 | 256 |
| 10/27/2028 | 266 |
| 11/11/2028 | 286 |
| 11/26/2028 | 290 |
| 12/11/2028 | 295 |
| 12/26/2028 | 299 |
| 1/10/2029 | 295 |
| 1/25/2029 | 292 |
| 2/9/2029 | 289 |

Adapted from WQCD, 2016

| | |
|---|---|
| **Ambient based standard, Adopted 2017** | **257 ug/L** |
| Assessed (2023-2025) 50th % | 272 ug/L |
| Sample Size | 20 |
| Outcome | Exceeded |
| Lower Confidence Limit Factor, **90%** Confidence Interval | 0.329 |
| LCL Concentration for Assessed (2023-2025) 50th % | 259 ug/L |
| Outcome | Exceeded |

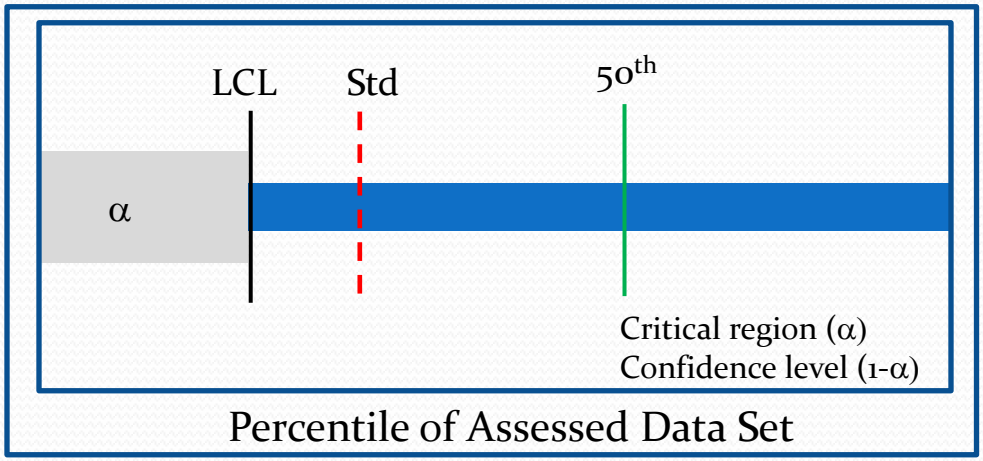


# Hypothetical Assessment for Madison West Yellowstone (4)
## 95% Confidence –Broader Confidence Interval

| Date | TR Arsenic (ug/L) |
|---|---|
| 4/30/2028 | 295 |
| 5/15/2028 | 270 |
| 5/30/2028 | 274 |
| 6/14/2028 | 273 |
| 6/29/2028 | 271 |
| 7/14/2028 | 249 |
| 7/29/2028 | 246 |
| 8/13/2028 | 248 |
| 8/28/2028 | 246 |
| 9/12/2028 | 252 |
| 9/27/2028 | 253 |
| 10/12/2028 | 256 |
| 10/27/2028 | 266 |
| 11/11/2028 | 286 |
| 11/26/2028 | 290 |
| 12/11/2028 | 295 |
| 12/26/2028 | 299 |
| 1/10/2029 | 295 |
| 1/25/2029 | 292 |
| 2/9/2029 | 289 |

Adapted from WQCD, 2016

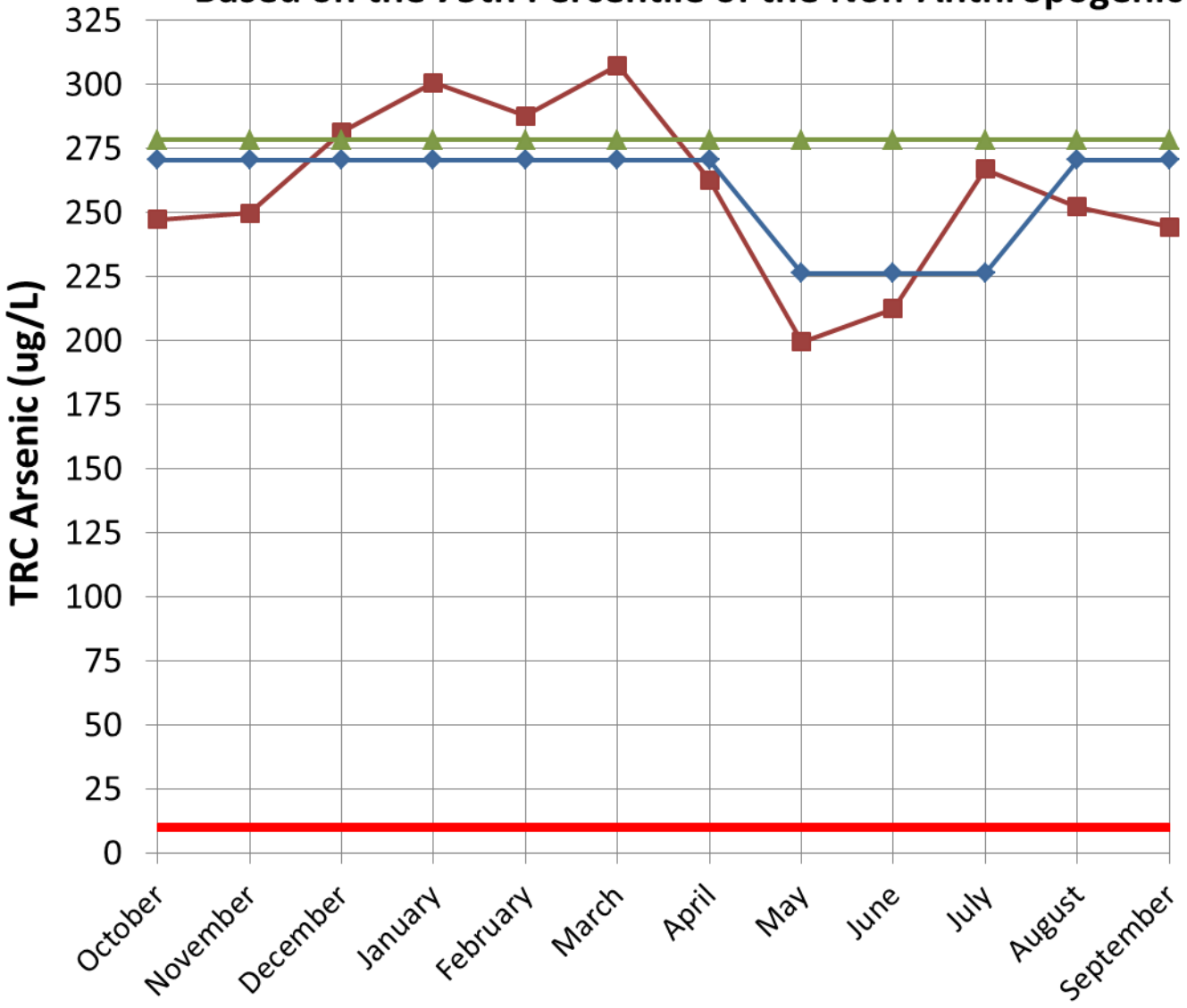
| | |
|---|---|
| **Ambient based standard, Adopted 2017** | **257 ug/L** |
| Assessed (2023-2025) 50th % | 272 ug/L |
| Sample Size | 20 |
| Outcome | Exceeded |
| Lower Confidence Limit Factor, **95%** Confidence Interval | 0.292 |
| LCL Concentration for Assessed (2023-2025) 50th % | 255 ug/L |
| Outcome | Not Exceeded |



# Basement Slides

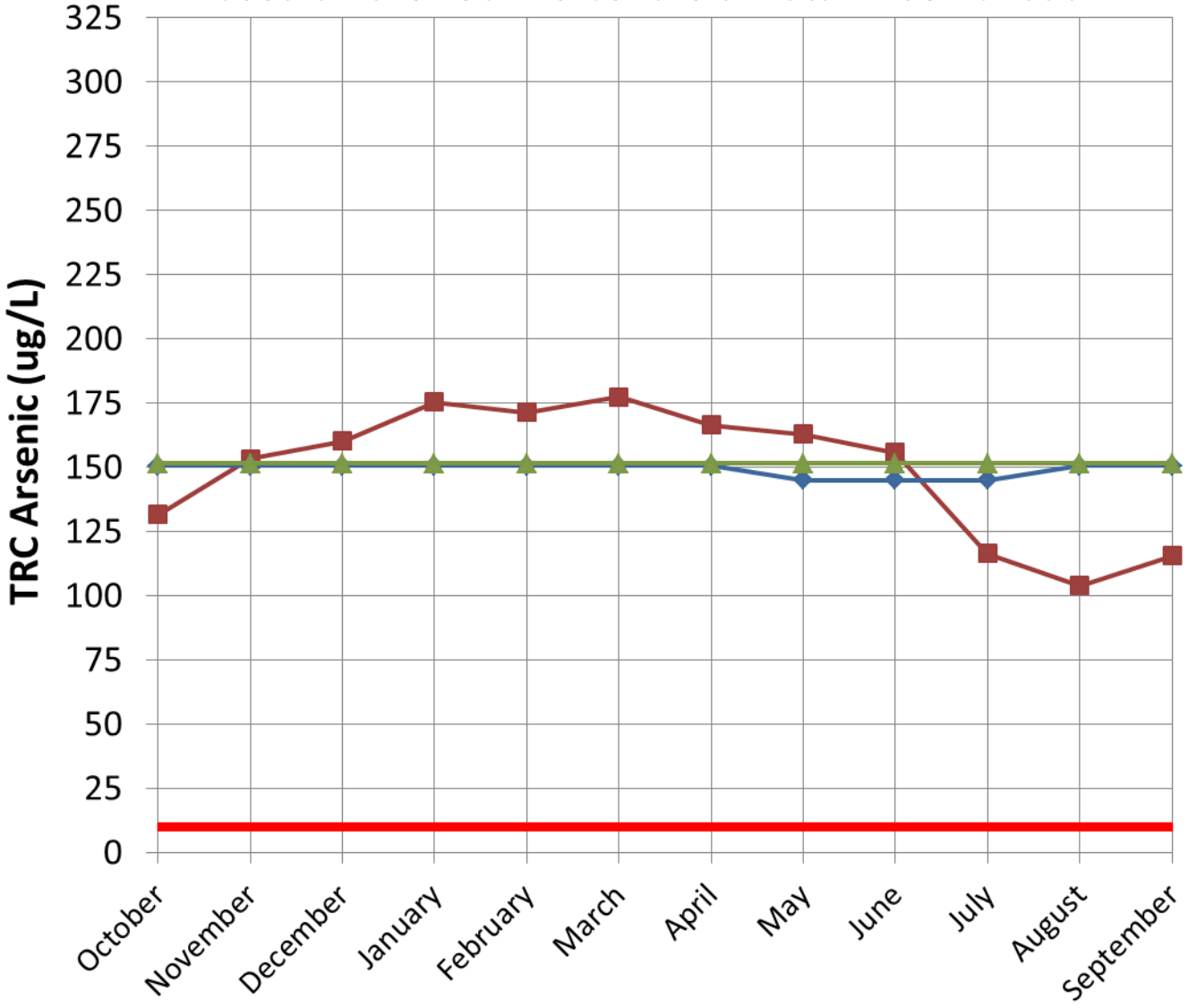
Not to be presented unless asked

# Proposed Criterion for Madison River, West Yellowstone to Below Hebgen Lake, Based on the 75th Percentile of the Non-Anthropogenic Condition



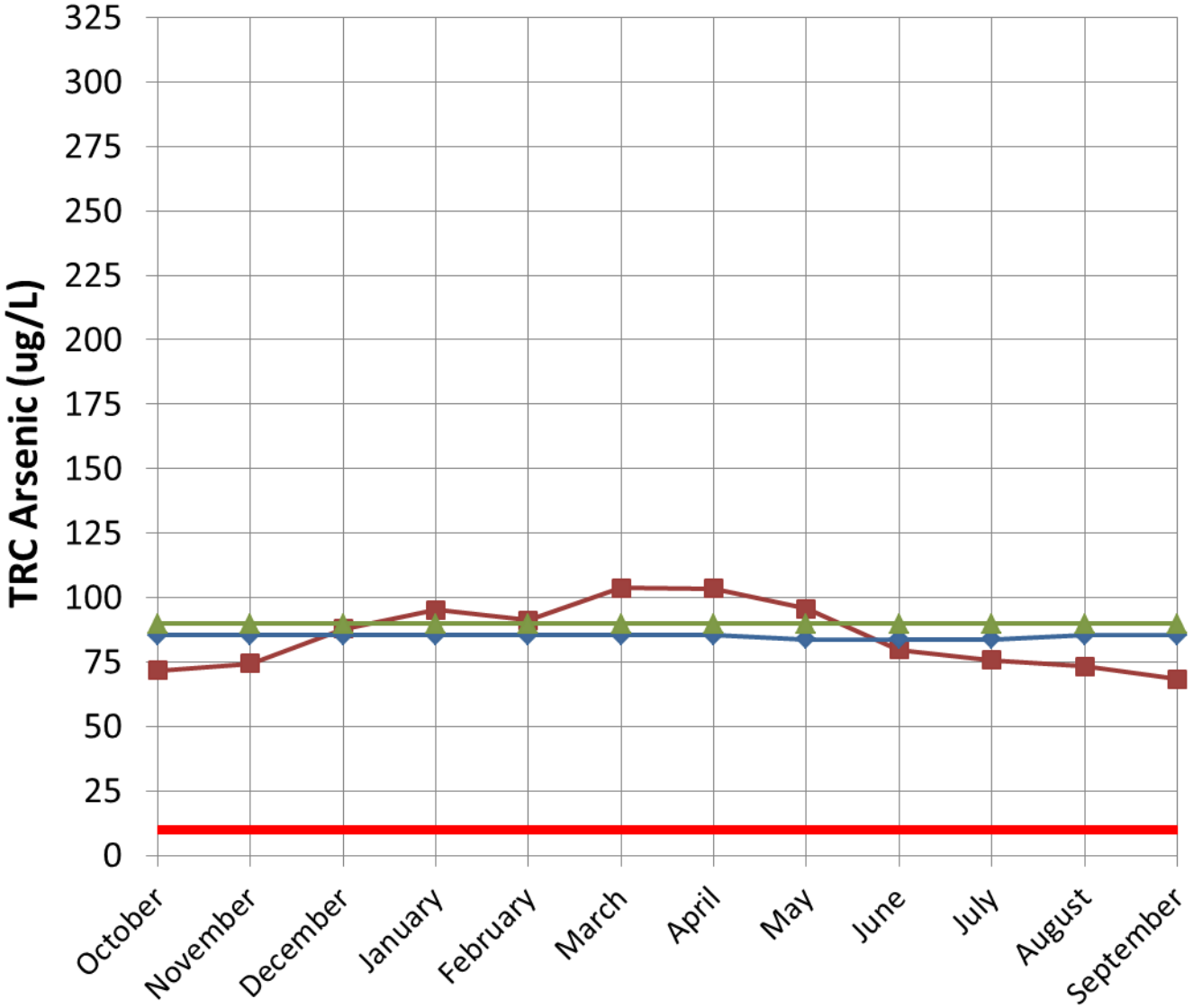

Total arsenic loads modeled using USGS LOADEST, data from 1995-2015. Nonanthropogenic concentrations calculated from the 75th percentile of total arsenic loads and median flow rates for the Madison. Anthopogenic loads are based on an average monthly or seasonal estimate.

# Madison River, Below Hebgen Lake to Below Ennis Lake Based on the 75th Percentile of Total Arsenic Load



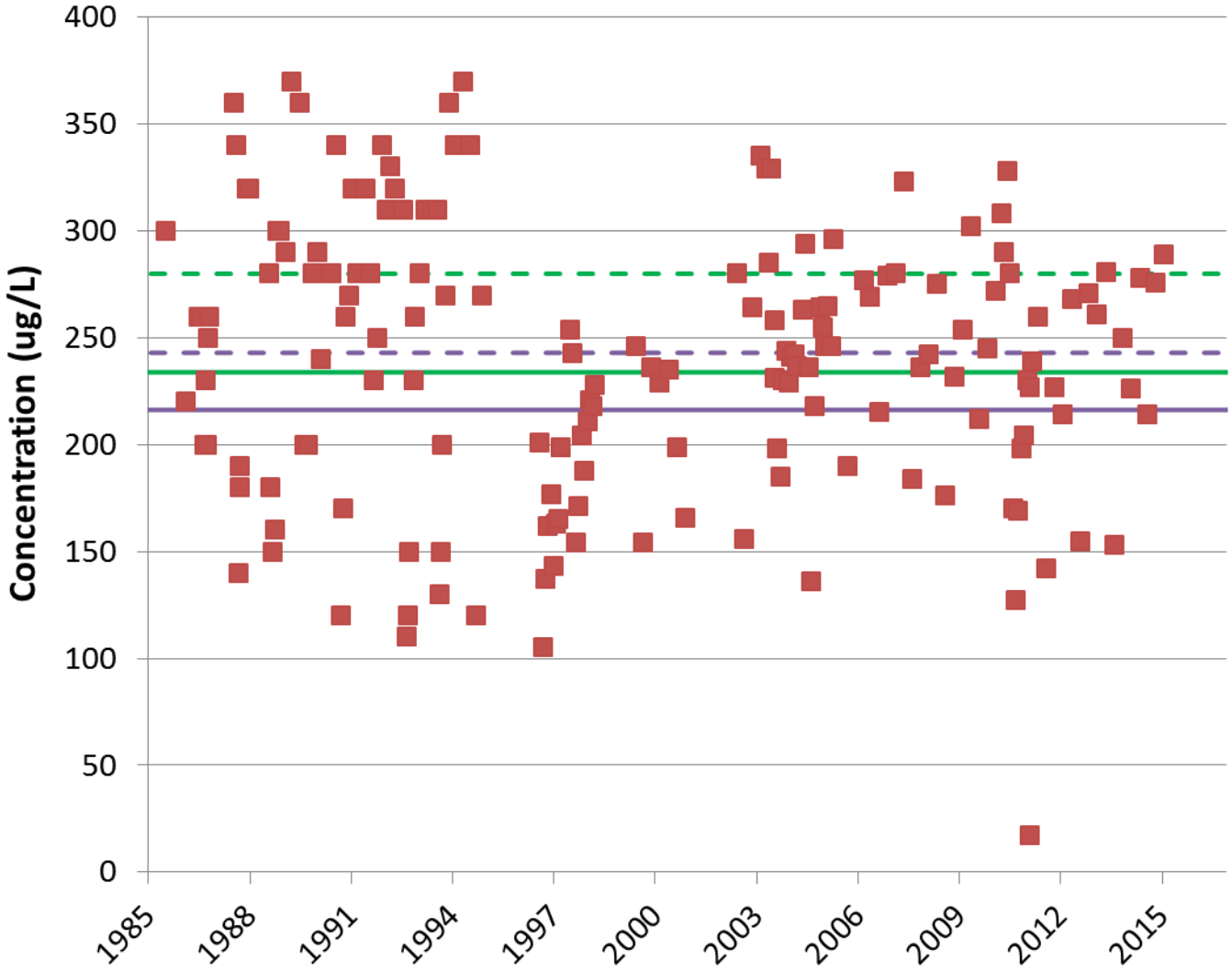

Total arsenic loads modeled using USGS LOADEST, data from 1995-2015. Nonanthropogenic concentrations calculated from the 75th percentile of total arsenic loads and median flow rates for the Madison. Anthopogenic loads are based on an average monthly or seasonal estimate.

# Madison River,
# Below Ennis Lake to Mouth of Missouri River
# Based on the 75th Percentile of Total Arsenic Load




Total arsenic loads modeled using USGS LOADEST usind data from 1995-2015. Nonanthropogenic concentrations calculated from the 75th percentile of total arsenic loads and median flow rates for the Madison. Anthopogenic loads are based on an average monthly or

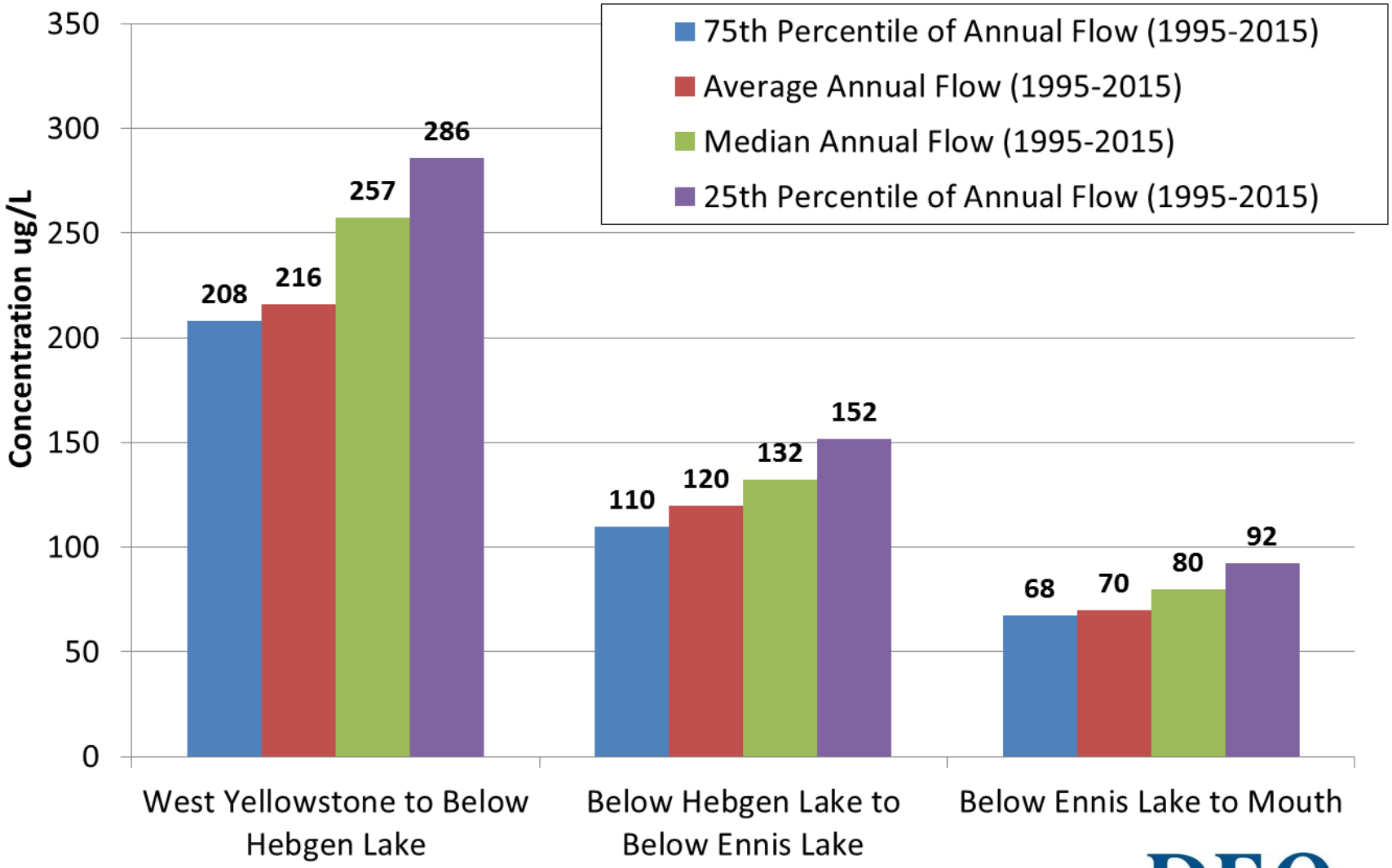
# Proposed Criteria Compared to Actual Data - Madison West Yellowstone to Below Hebgen Lake



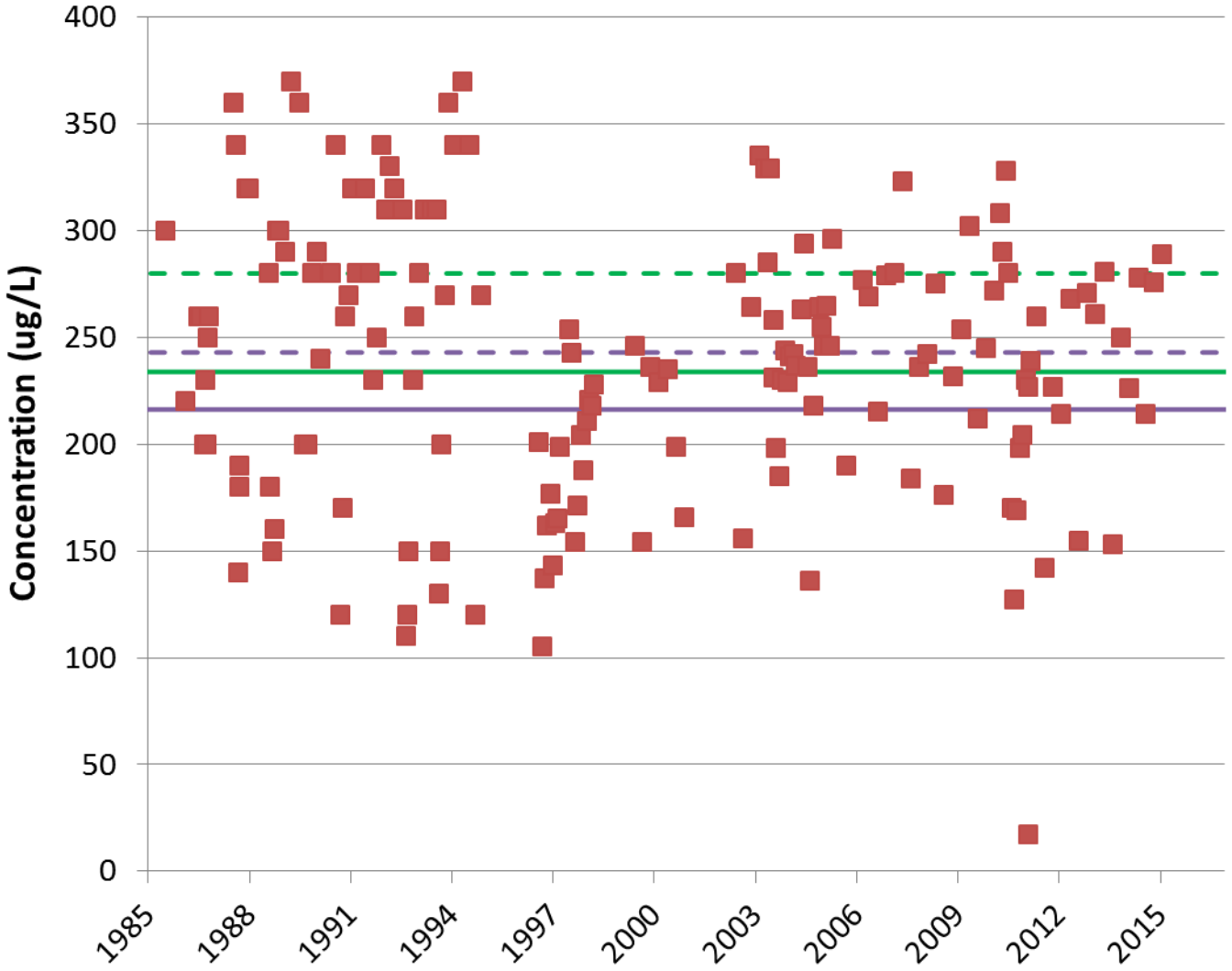

- Measured Concentrations above Hebgen Lake
- 50th Percentile of Measured Concentrations
- 75th Percentile of Measured Concentrations
- Proposed Criteria - 50th Percentile
- Proposed Criteria - 75th Percentile

Proposed Standards calculated using modeled results and **Average** of daily flow data (1995-2015)

## Proposed Annual Nonanthropogenic Criterion for various Madison River Flow Conditions, Based on 50th Percentile of Arsenic Load

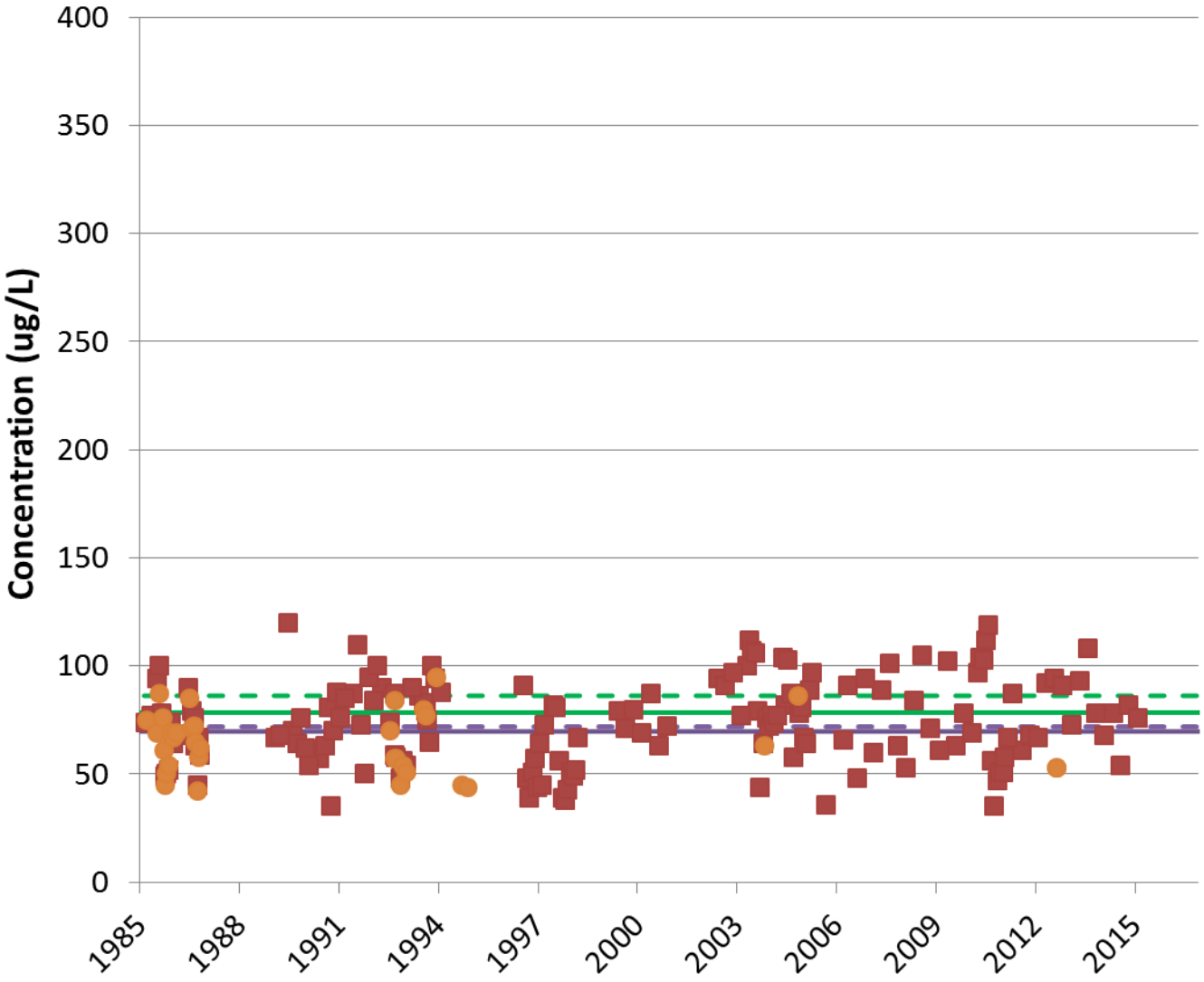


# Criteria Compared to Actual Data - Madison West Yellowstone to Below Hebgen Lake




Criteria calculated using modeled results and **Average** of daily flow data (1995-2015)

# Proposed Criteria Compared to Actual Data - Below Ennis Lake to Mouth of Missouri




Standards calculated using modeled results and **Average** of Daily Flow Data (1995-2015)

# Lower Confidence Level (LCL)